AIM Mission Overview

James M. Russell III

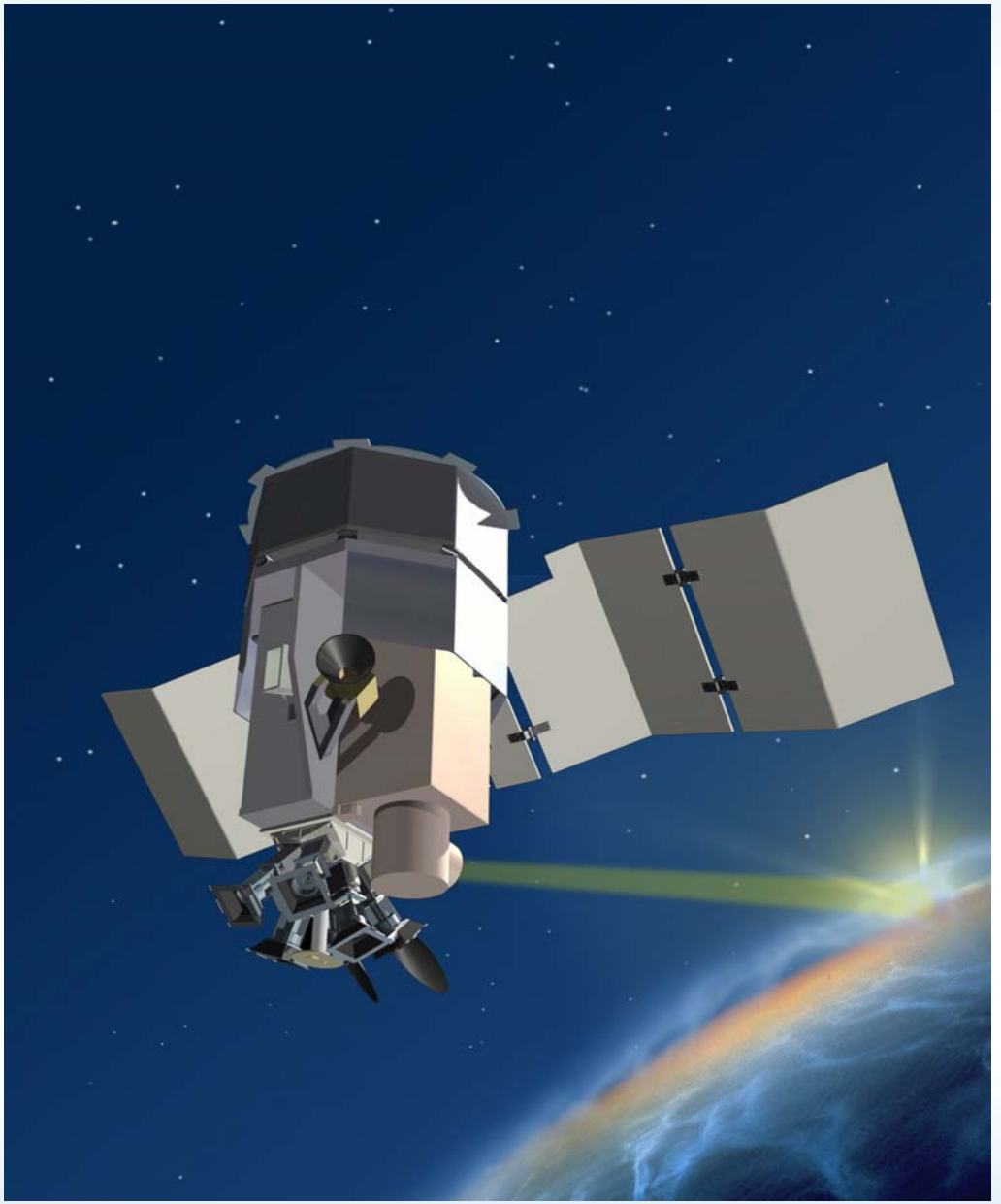
Principal Investigator
Hampton University

Scott M. Bailey

Deputy Principal Investigator
University of Alaska

Aeronomy of Ice in the Mesosphere (AIM)

- **Unprecedented advance in understanding of noctilucent clouds**
  - **Solar Occultation**
  - **Limb scattered sunlight**
  - **Panoramic UV nadir imaging**
  - **In-situ dust detection**
  - **Ball RS-300 spacecraft**
  - **State-of-the-art modeling**



AIM Science Team

Principal Investigator: James M. Russell III
Hampton University

Deputy PI: Scott M. Bailey
University of Alaska

Science Team

Gary Thomas, CU
David Rusch, CU
Christoph Englert, NRL
Patrick Espy, BAS
John Harlander, SCU
Michael Summers, GMU
Steven Eckermann, NRL
Cora Randall, CU
Mihály Horányi, CU
Mike Taylor, SDL
Larry Gordley, GATS
David Siskind, NRL
Michael Stevens, NRL
Robert Meier, NRL

AIM Team Working Relationships

- **Hampton University**
  - PI institution, prime contractor, manages program, NASA interface
- **University of Alaska, Fairbanks**
  - Co-PI assists PI in managing science, participates in decision making, oversees E/PO activities
- **University of Colorado – LASP**
  - Manages technical, cost and schedule implementation, conducts mission operations; IPA, CIPS and CDE; Hosts Co-Is
- **Ball Aerospace & Technologies Corp.: Spacecraft**
- **Utah State University – SDL: SOFIE, Hosts Co- I**
- **Naval Research Laboratory: SHIMMER, Hosts Co-Is**
- **GATS, Inc.: AIM Data Management, SOFIE PI**

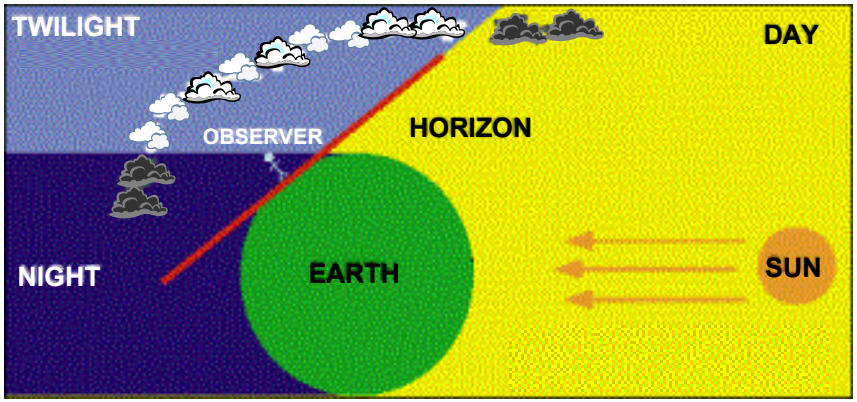
Aeronomy of Ice in the Mesosphere (AIM)

Tom Eklund, July 28, 2001, Valkeakoski, Finland

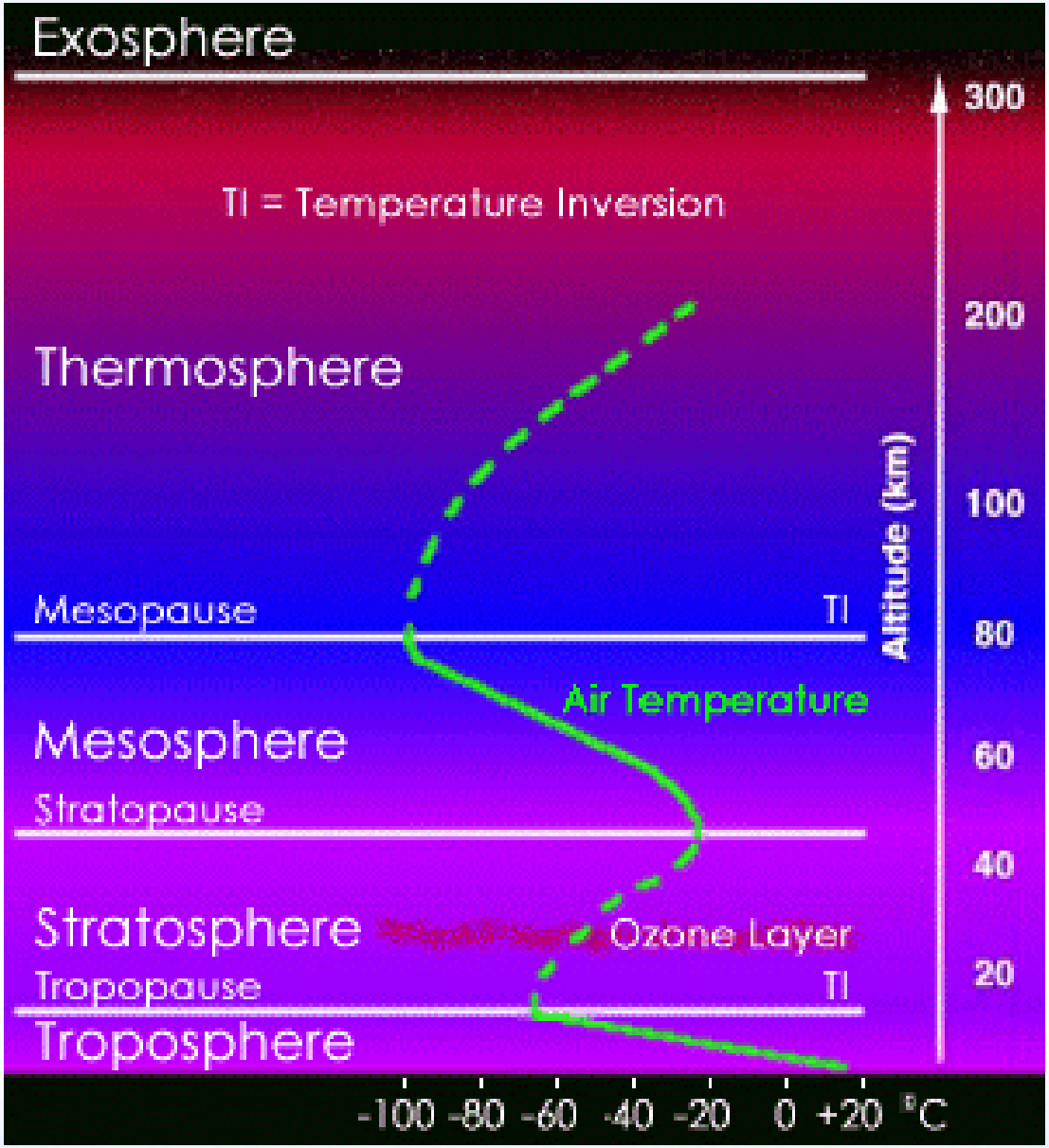
- **Ground-based observers: Noctilucent or "night shining" Clouds (NLCs)**
- **Satellite observers: Polar Mesospheric Clouds (PMCs)**

What are noctilucent or "night shining" clouds

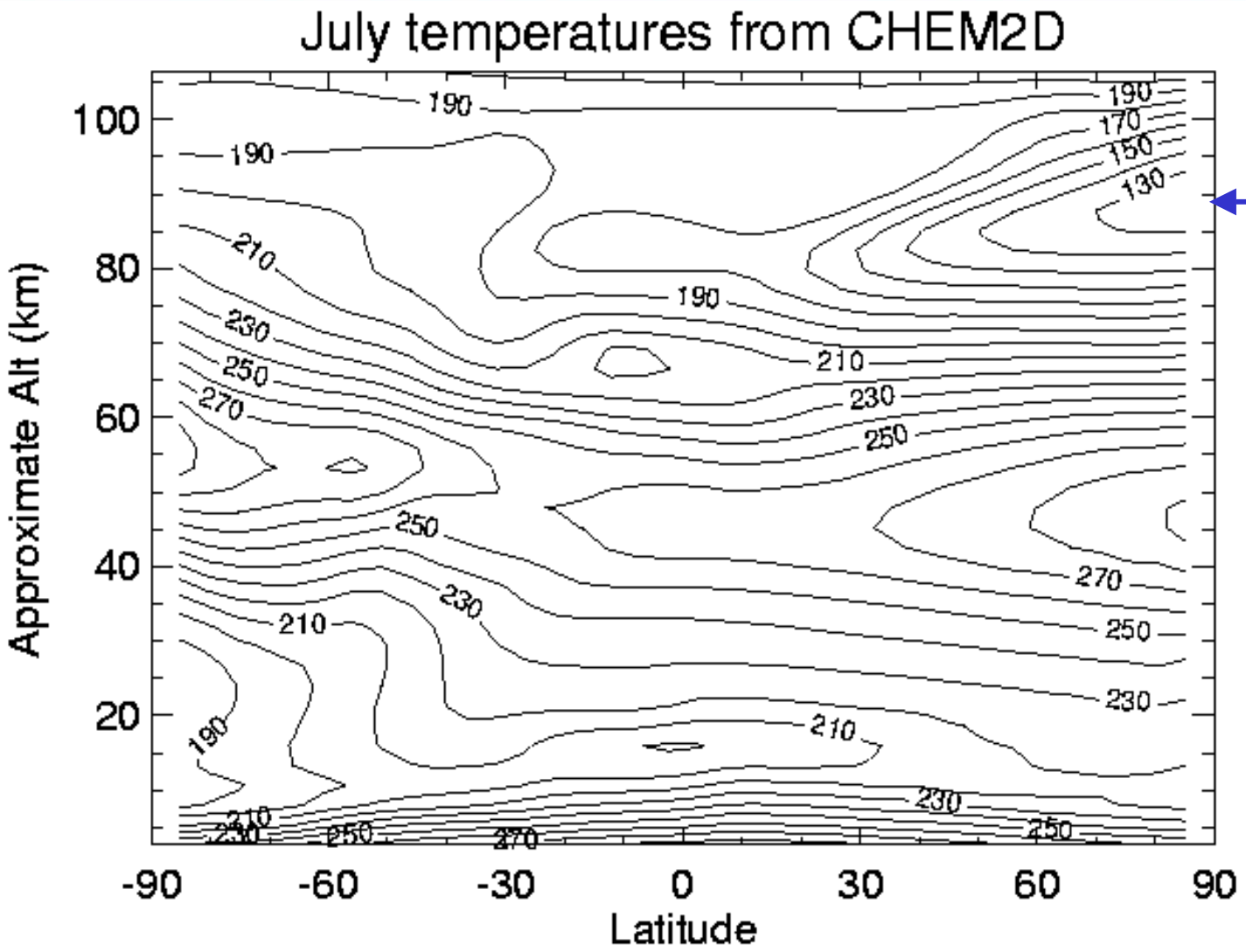
- Highest altitude clouds in our atmosphere (~ 82 km)
- Form at coldest place on Earth (~130 K) in polar summers
- First reported in 1885
- Have been increasing over the past 30 years



PMCs Occur Near the Cold Summer Mesopause



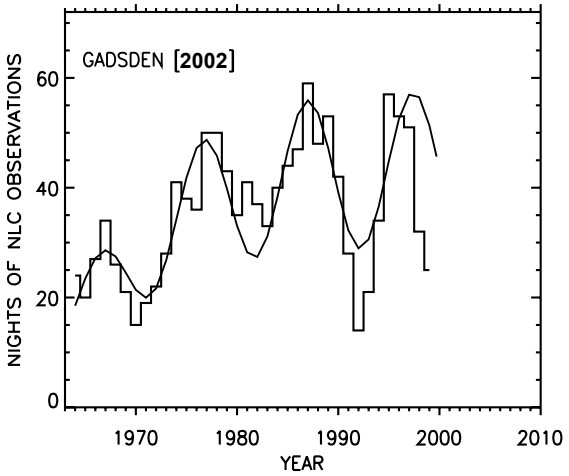
The Coldest Place on Earth: The Summer Mesopause



PMC's form in the coldest region of the atmosphere. The mesosphere is very sensitive to changes in atmospheric composition.

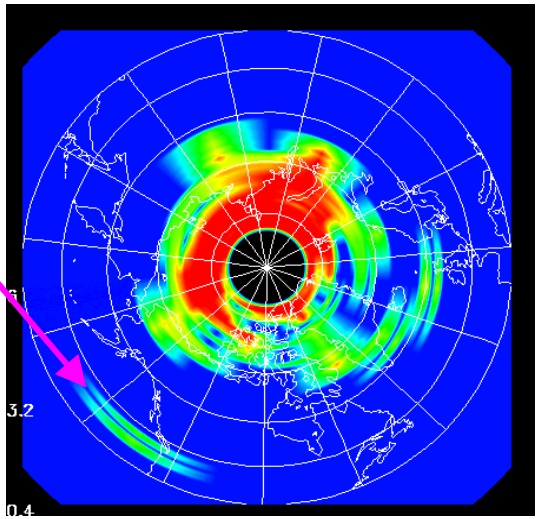
PMCs are changing: AIM is needed now

Increasing numbers and brighter clouds are observed



NLCs are moving equatorward

NLCs seen at 42°N for first time in history (Logan, Utah on June 22-23, 1999)

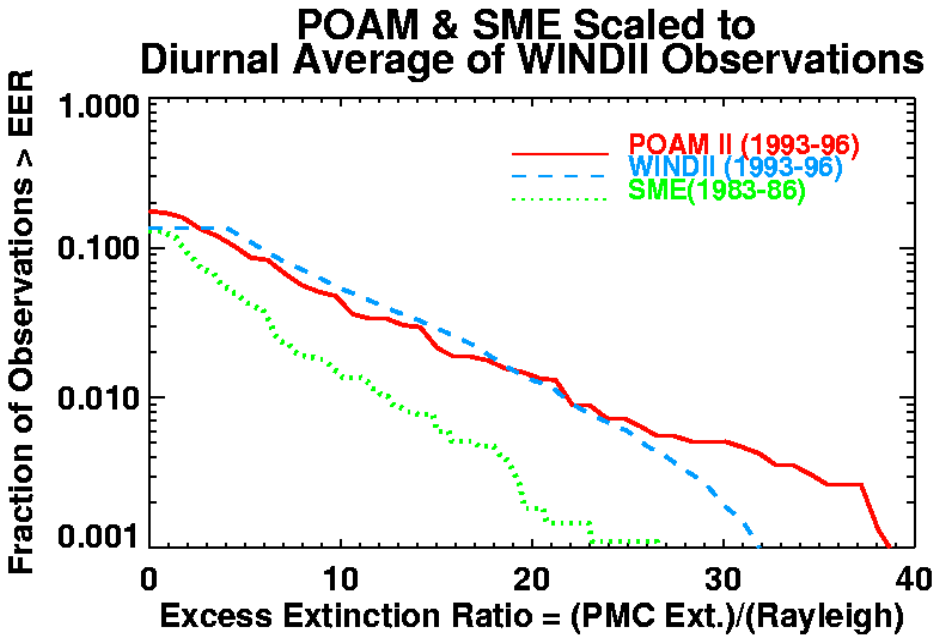


Mid-latitude PMCs seen by CU SNOE satellite. AIM images will be 100 X the SNOE spatial resolution.

AIM is unique because it will study a rapidly evolving geospace phenomenon

NLC changes need to be understood

- Why are NLCs increasing in frequency and brightness?
- Why have they been sighted at ~40°N for the last 3 consecutive summers when usually they are seen poleward of 55°?

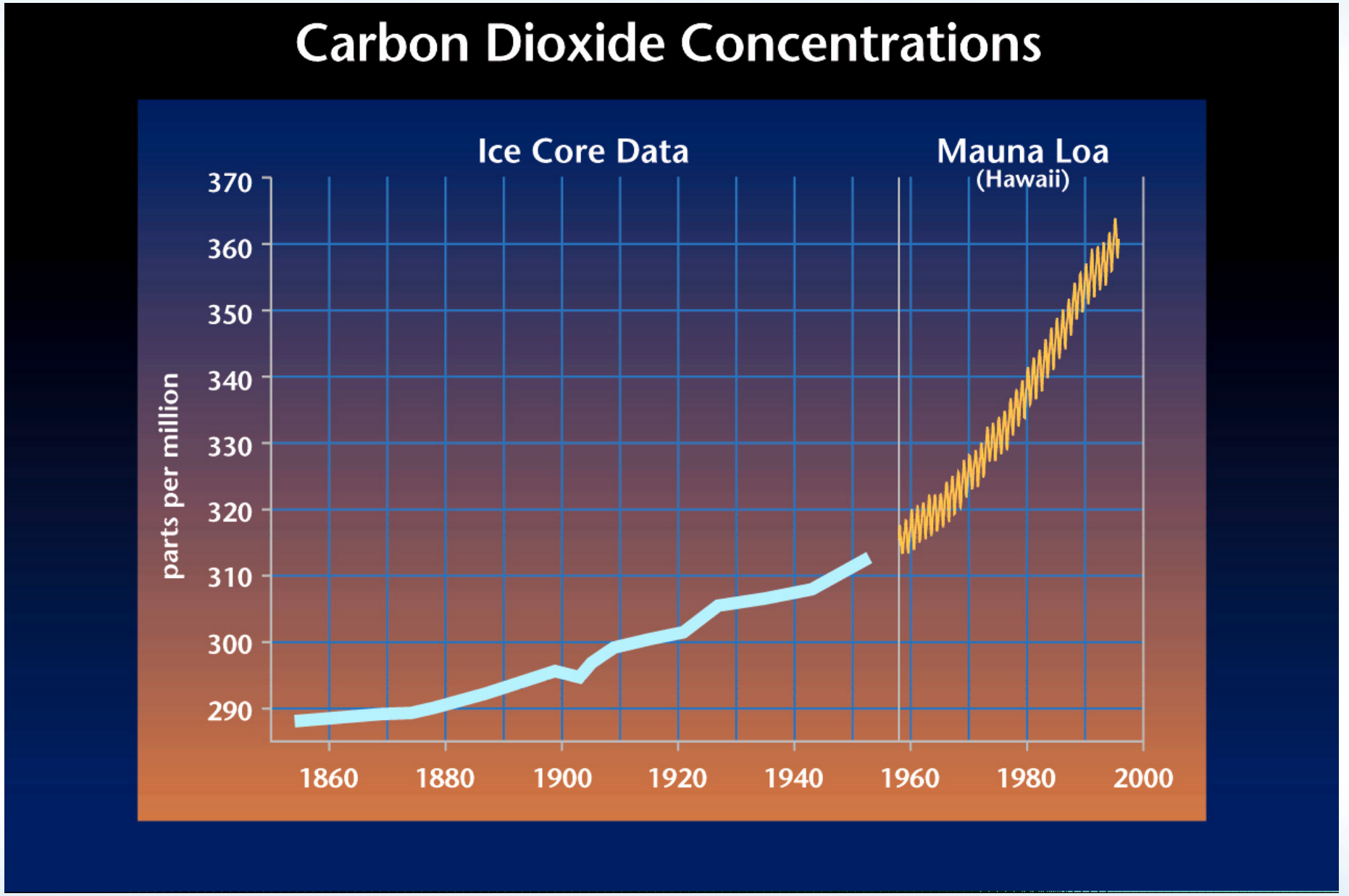


Are NLCs the "miner's canary" of global change in the upper atmosphere?

What do we know about NLC formation?

- PMC formation appears to require cold temperatures; thus increasing NLCs may be one result of global CO_2 increases
- Upper atmosphere cooling should accompany lower atmosphere warming, e.g., due to CO_2 buildup
- Limited satellite data suggest large mesospheric cooling; newer data give mixed results
- If T ↓ are not the cause, H_2O ↑ may be responsible; but H_2O Δ's appear to be too small
- Intense summer ascent causes enhanced H_2O and dramatic departures from radiative equilibrium that can cause cooling
- Poor knowledge exists of how NLCs nucleate, the environment for nucleation and how the mesosphere responds to forcings
- H_2O chemistry must be important since major NLCs consist of water ice

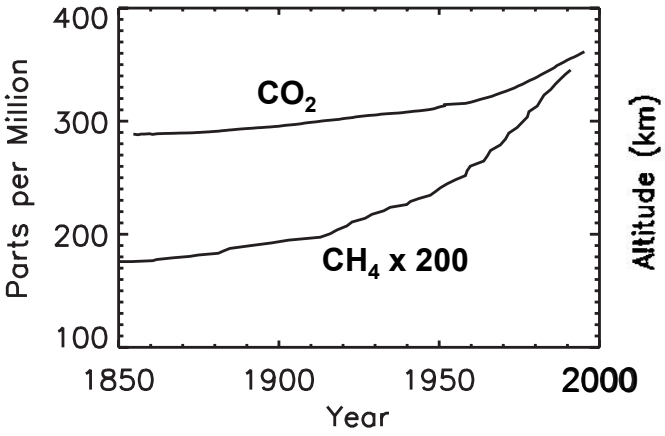
Carbon dioxide has increased by ~25% since 1860.



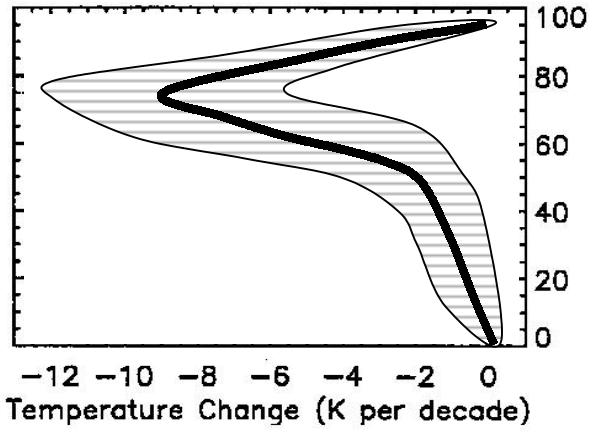
A changing PMC climatology is key AIM science driver

What is causing PMCs to vary?

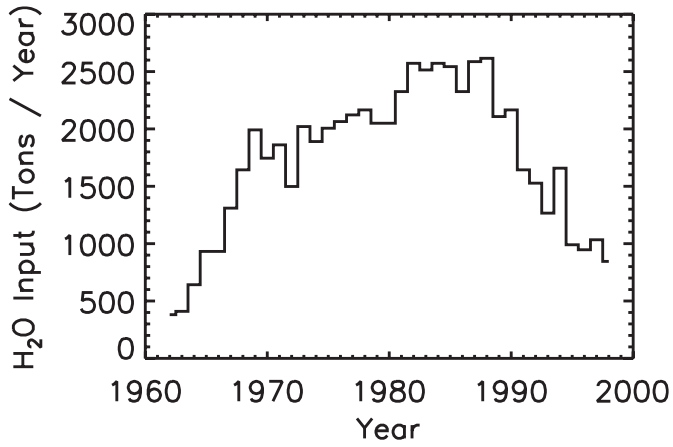
Increased atmospheric CO_2 and CH_4?



Cooling in the upper atmosphere?



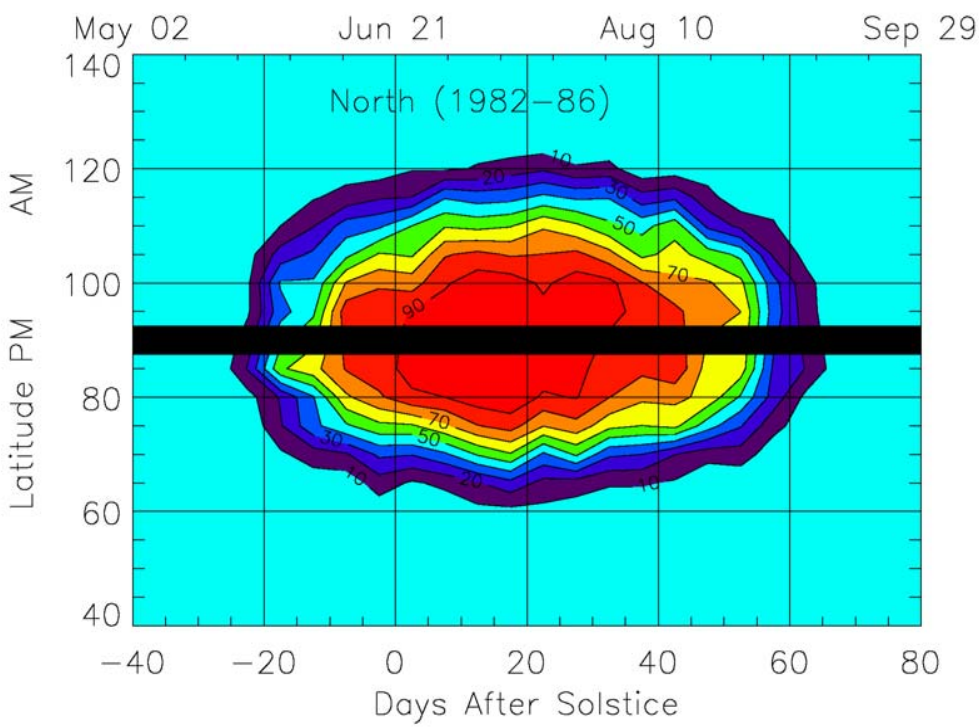
Water exhausted by rockets?

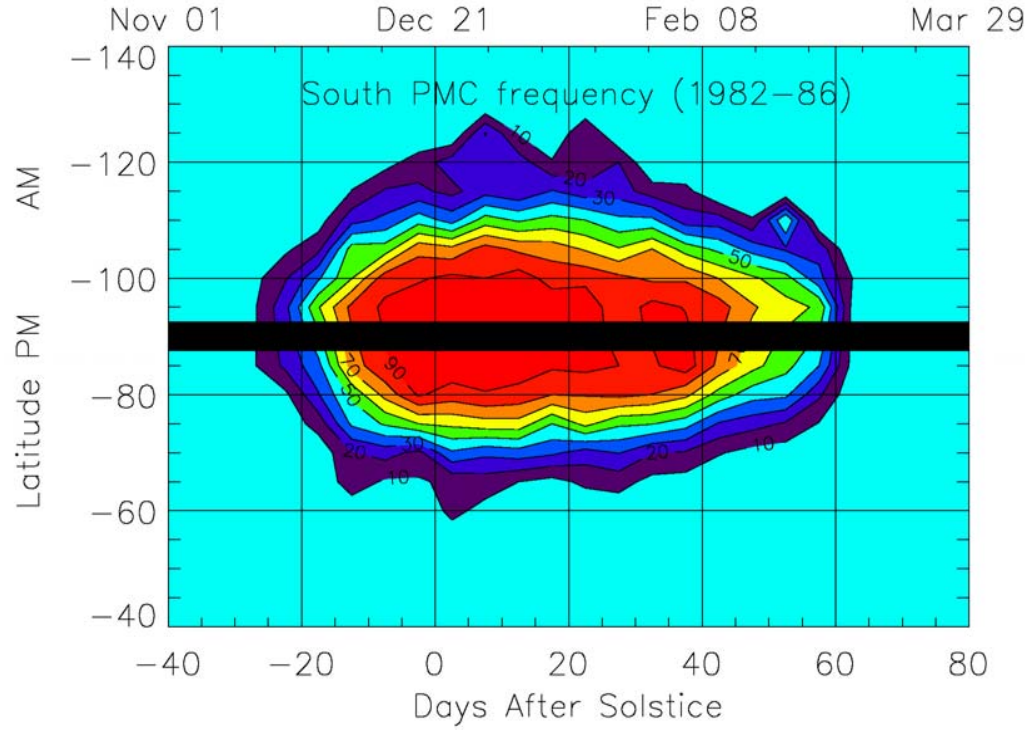


AIM will establish the relationship between PMCs and their environment. This will form the basis for the study of long-term change in the mesosphere.

SME defined the PMC climatology 20 years ago

PMCs usually occur in the polar regions during a 12 week period centered about two weeks after soltice





Solar Mesosphere Explorer Five year PMC climatology Thomas et al.

Critical questions must be addressed

Why do they form?

Why do they vary?

What is the role of temperature, H_2O, dynamics, and chemistry?

Do extraterrestrial forcings such as cosmic dust or ionization play a role?

Why have they appeared at such low latitudes (~ 40°N) in the past 3 NH summers?

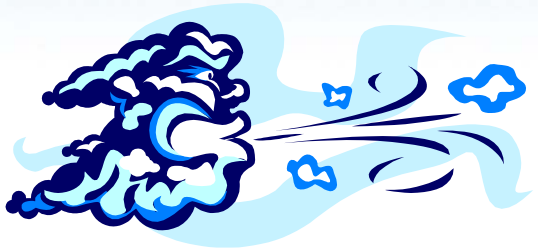
Is there a relationship to global change?

AIM goals are clearly defined

- Resolve why PMCs form and how and why they vary
- Quantify the connection between these clouds and the meteorology of the polar mesosphere by measuring the thermal, chemical and dynamical environment in which PMCs form
- Provide the basis for study of long-term variability in the mesospheric climate and its relationship to global change

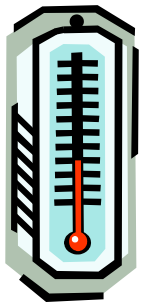
The fundamental question: Why do PMCs form and vary?

AIM will provide the answer

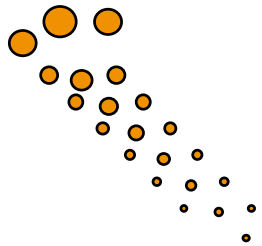


1. Microphysics

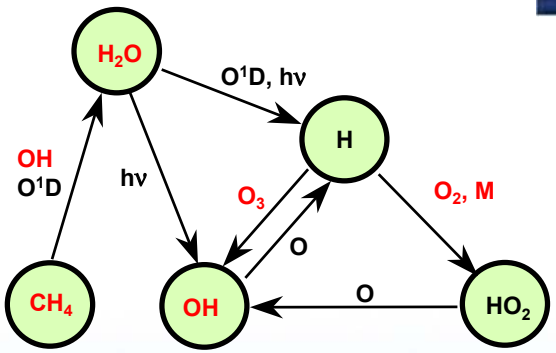
2. Gravity Wave Effects



3. Temperature Variability



5. Nucleation Environment



4. Chemistry

6. Long-term Mesospheric Change - What is needed?

AIM will provide a critical science result

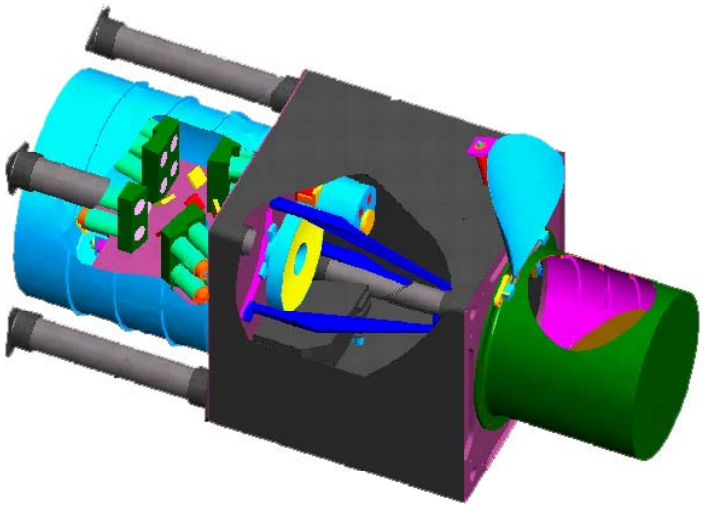
- **An understanding of clouds at the edge of space that will provide the basis for study of long-term change:**
  - **Microphysics**
  - **Evolution**
  - **Morphology**
  - **Effects of solar and extraterrestrial forcing**
  - **Environment in which they form (thermal, chemical, dynamical)**

Timo Leponiemi, 2001

AIM measurements provided by four instruments

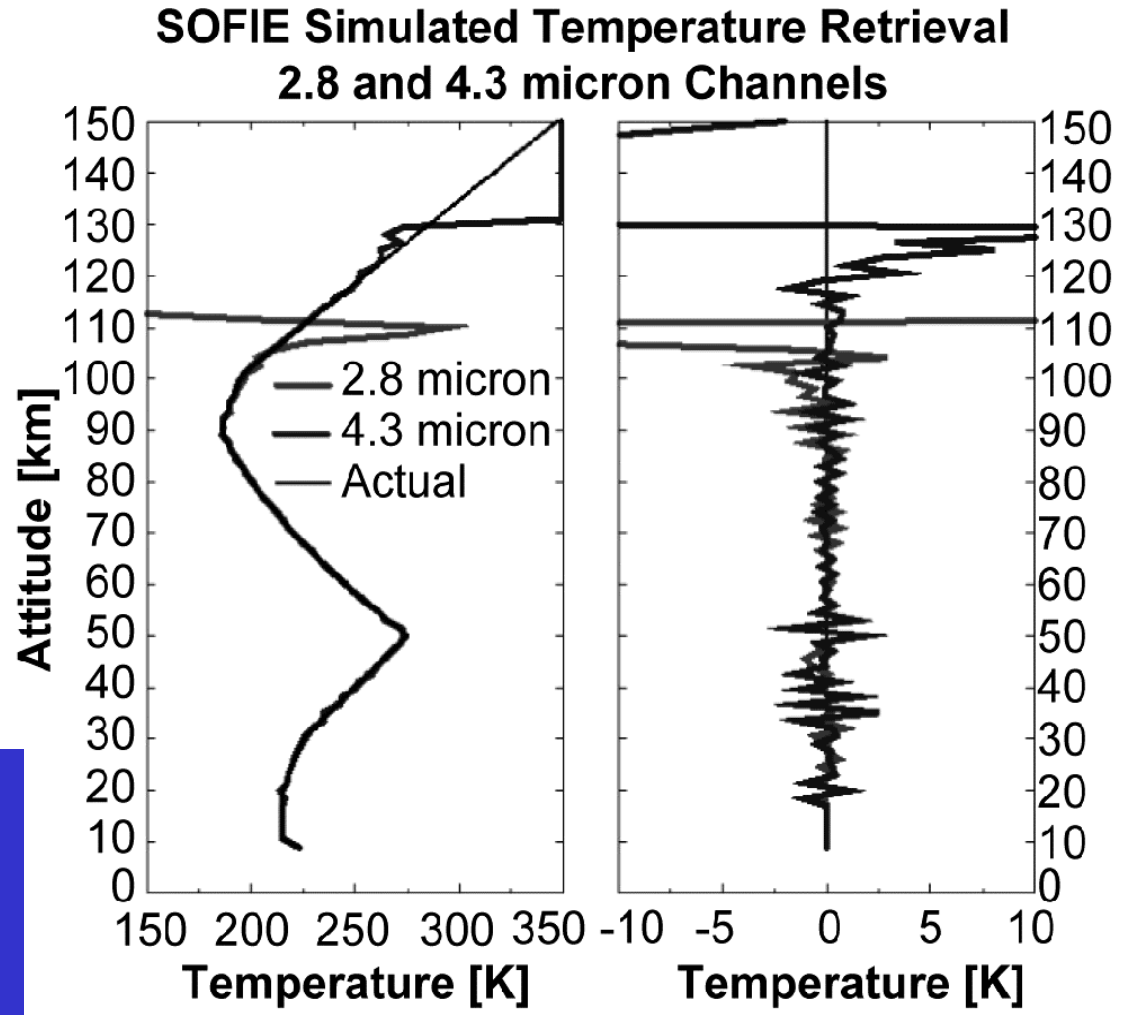
- **SOFIE** — Solar occultation
- **SHIMMER** — Limb scattered sunlight
- **CIPS** — High resolution panoramic images over the entire polar cap
- **CDE** — Cosmic dust influx

SOFIE: Solar Occultation for Ice Experiment

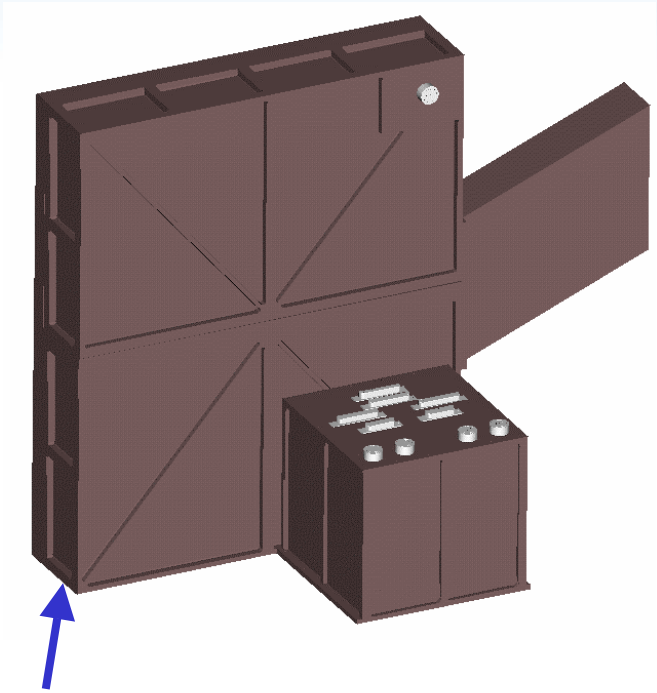


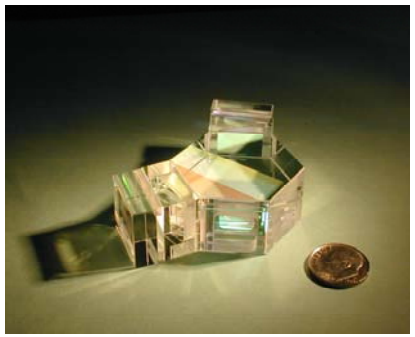
SOFIE: An 8-channel differential absorption radiometer

Measures: T, PMC's, CO_2, CH_4, NO, O_3, aerosols

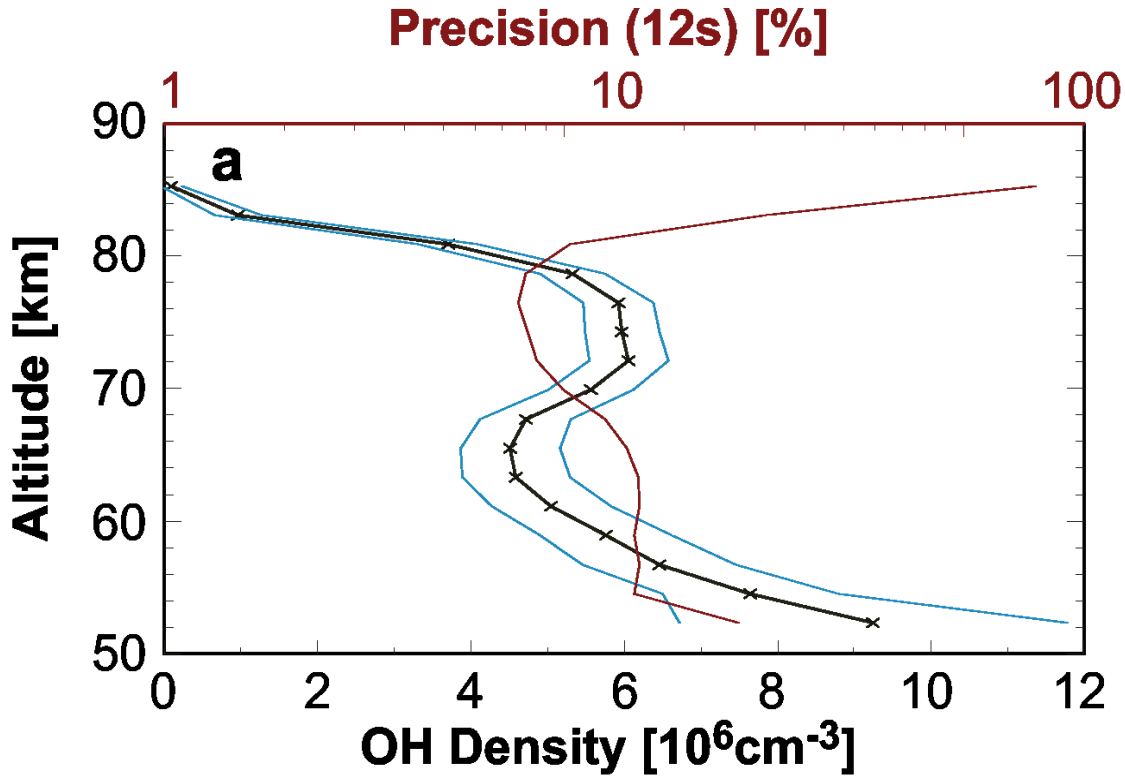


SHIMMER: Spatial Heterodyne Imager for Mesospheric Radicals





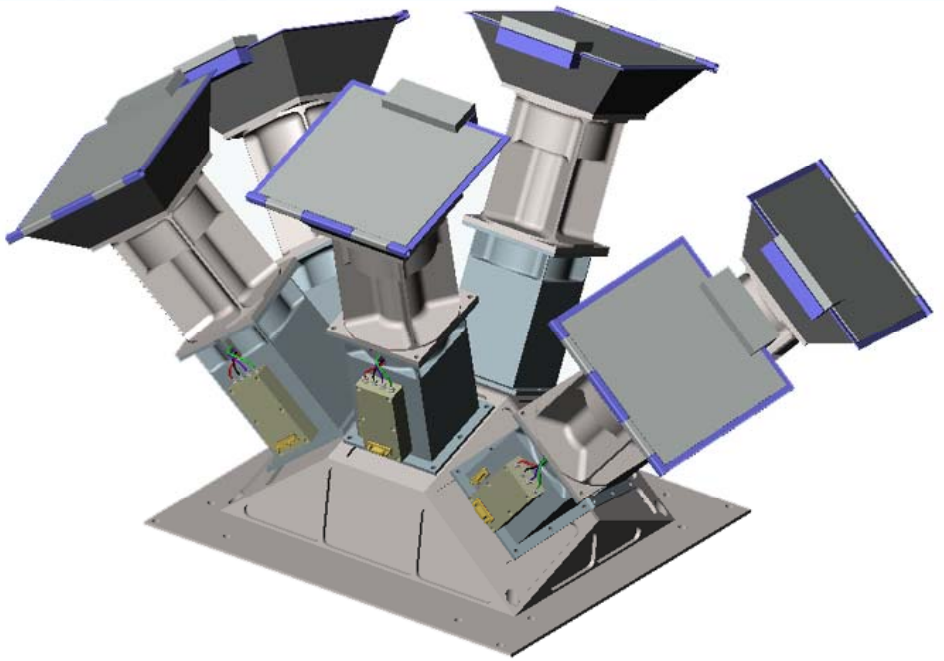
Monolithic Interferometer

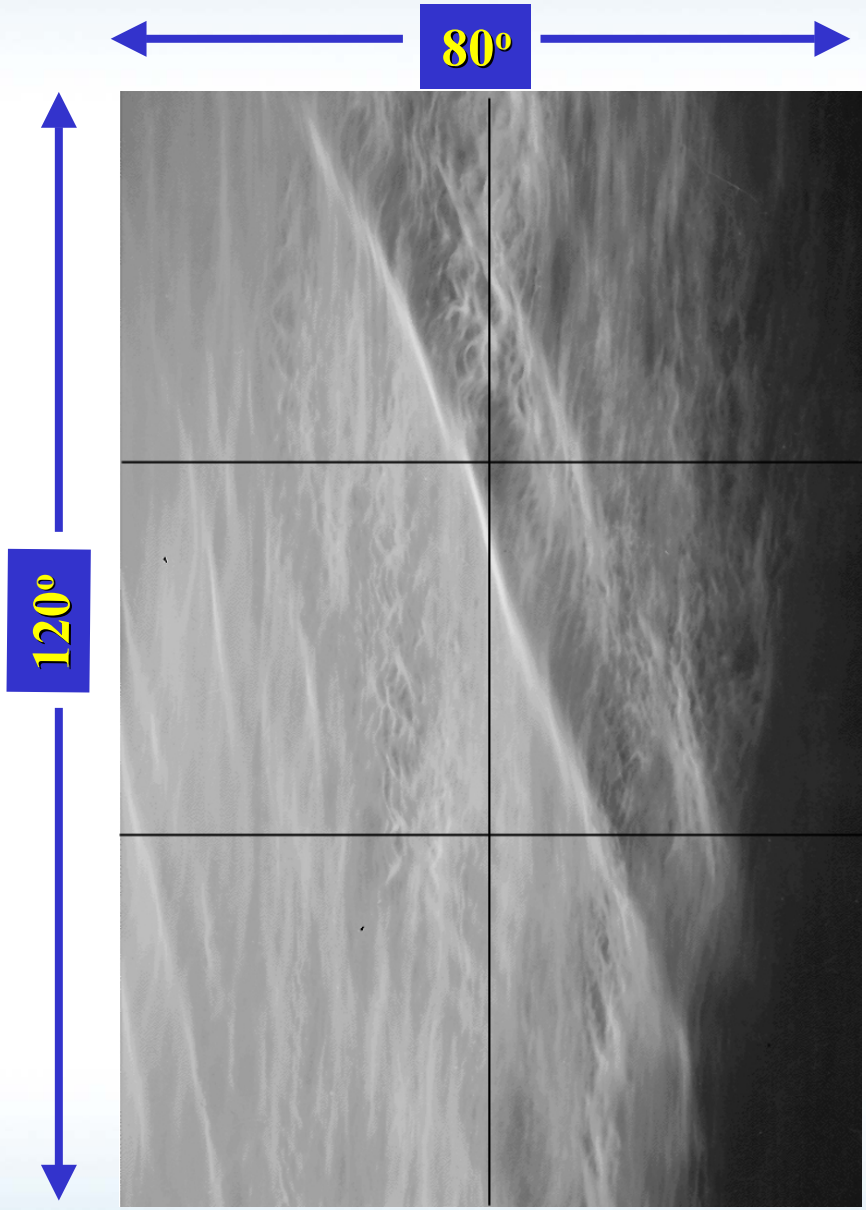


SHIMMER: A limb imaging interferometer measuring OH fluorescent spectra

Measures: T, OH, and PMC's.

CIPS: Cloud Imaging and Particle Size Instrument

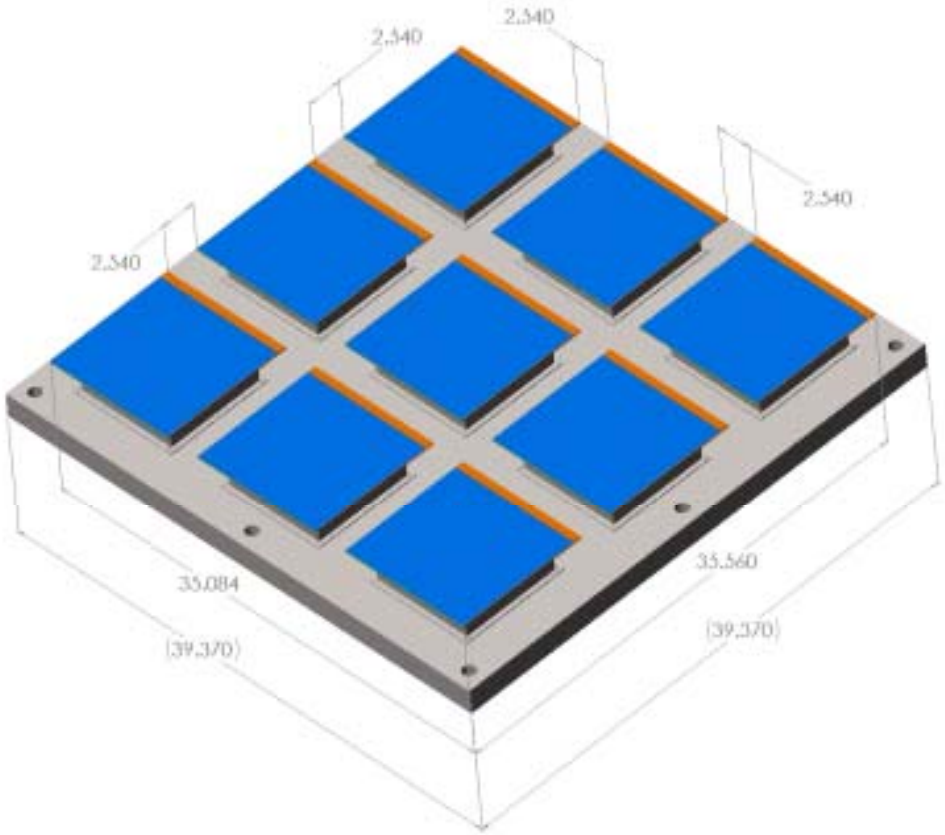


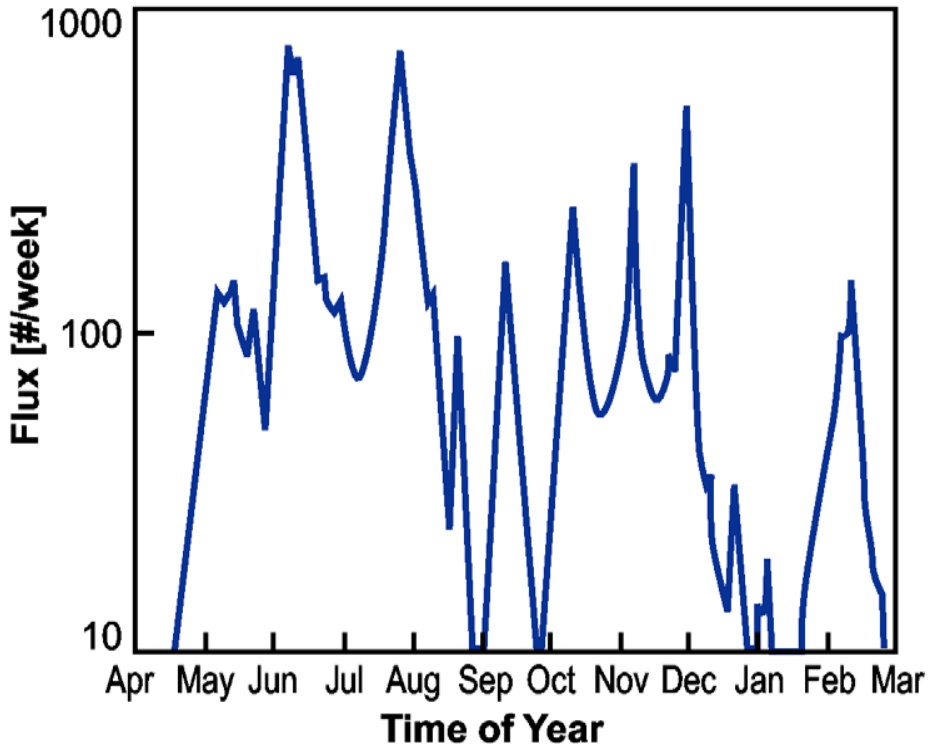


CIPS: Panoramic UV (265 nm) nadir imager

Provides: PMC images and Cloud properties with 2 km resolution. Total FOV is 1440 x 960 km at 83 km altitude

CDE: Cosmic Dust Experiment



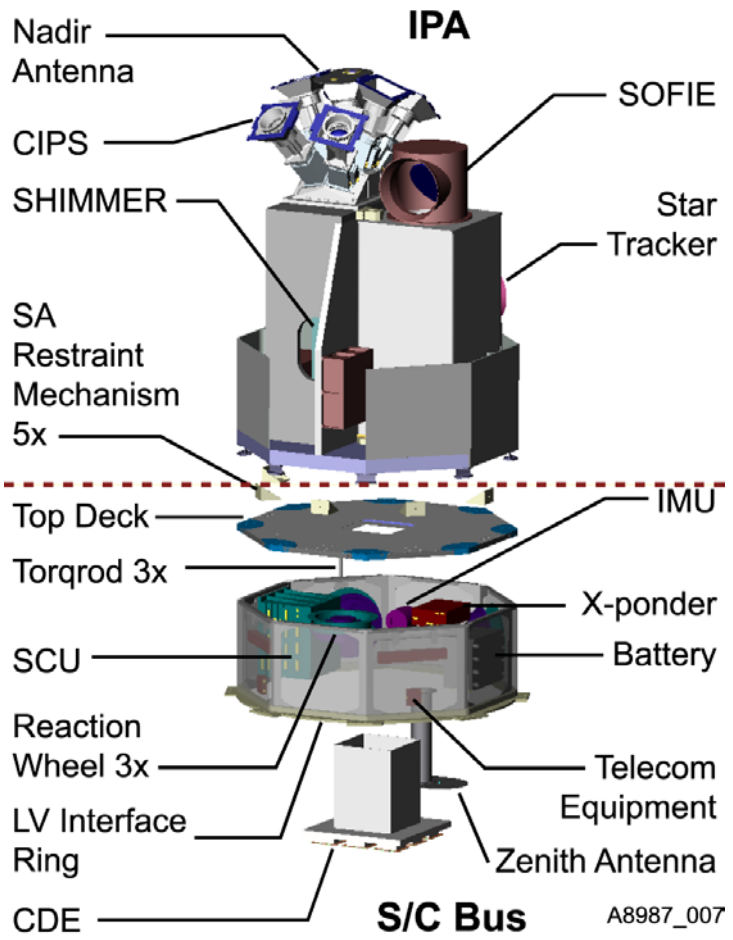


CDE predicted fluxes.

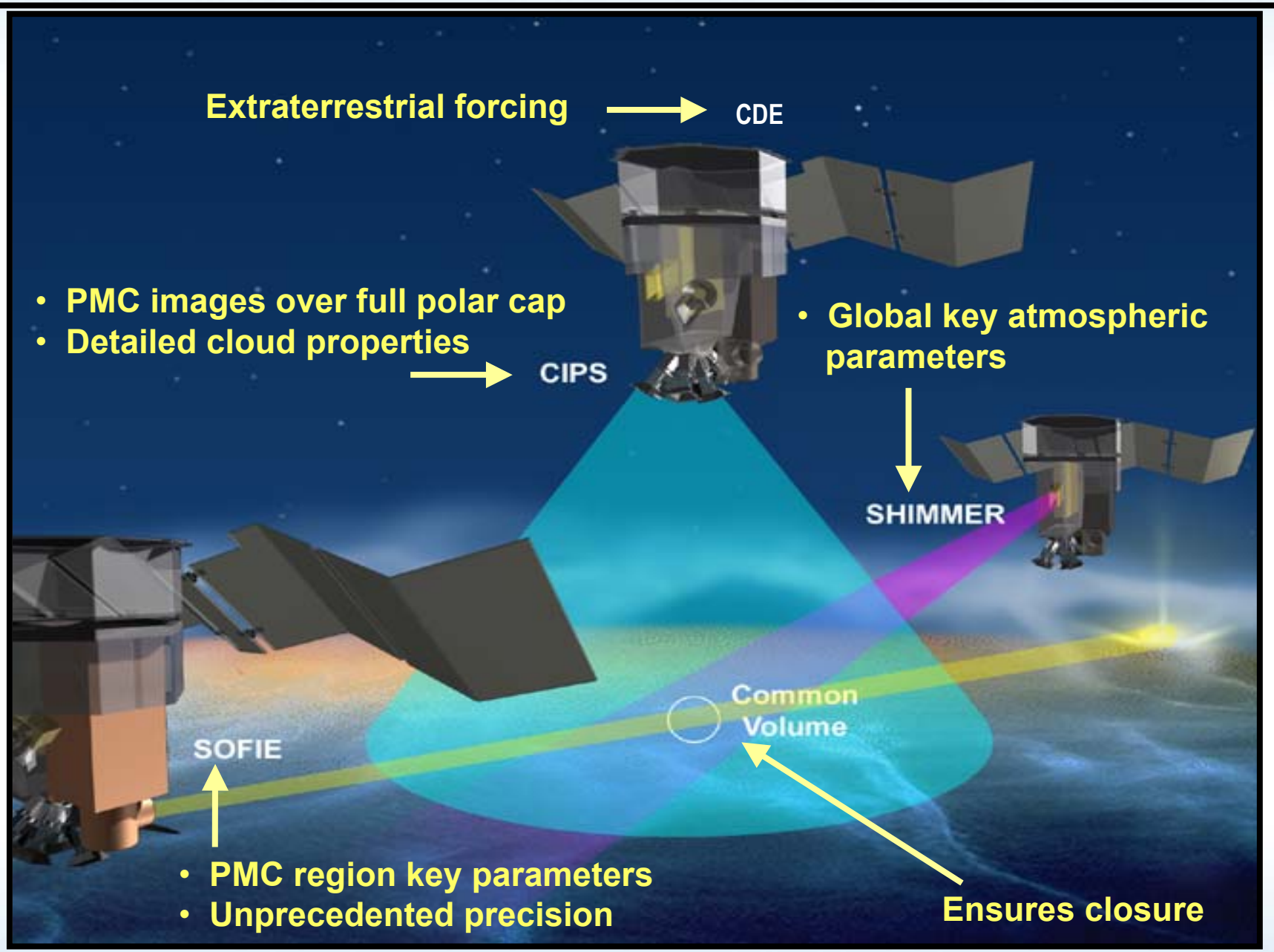
CDE: In-situ dust detector
Measures: Cosmic dust input to PMC region

AIM RS300 satisfies requirements with low risk

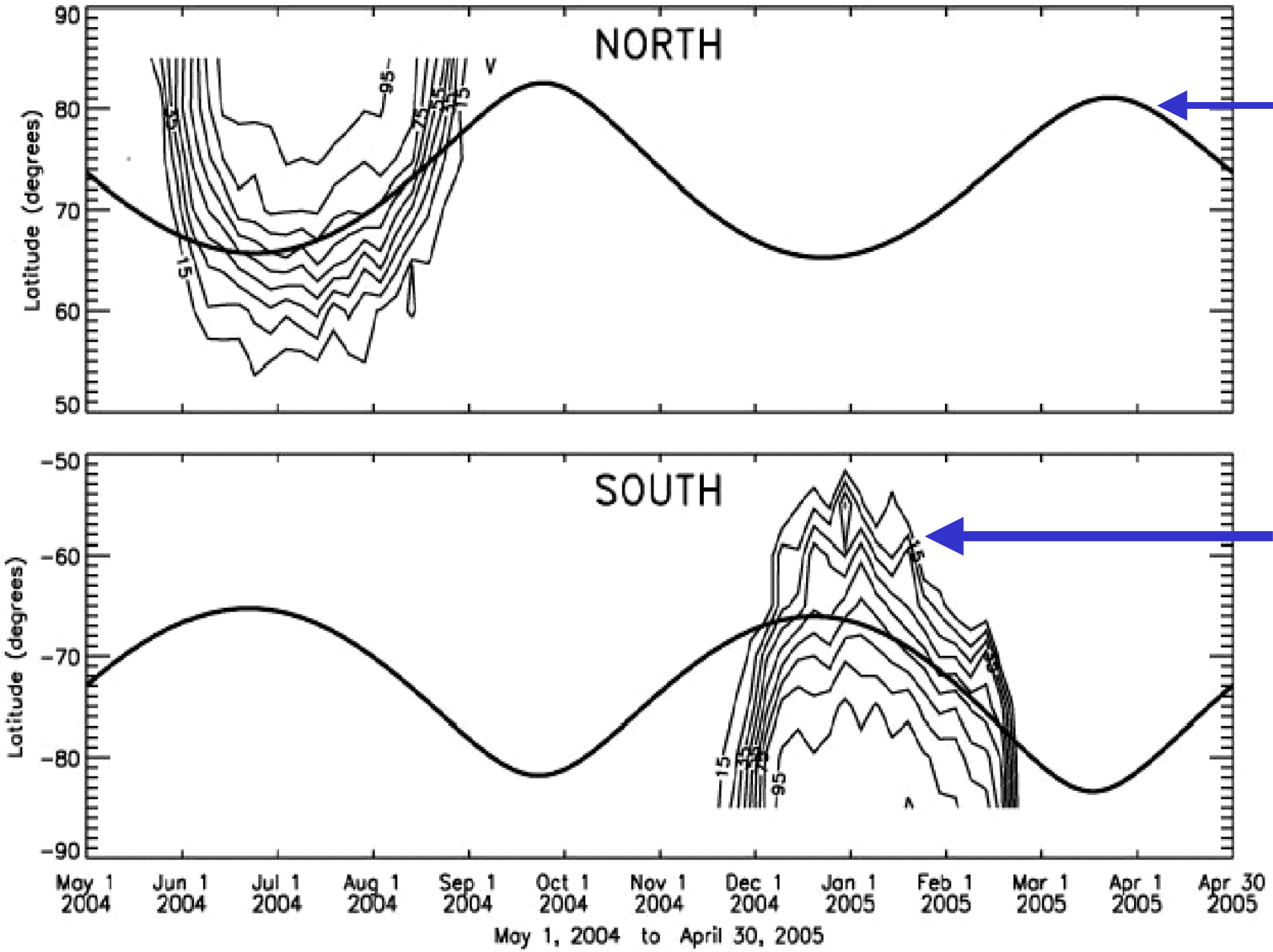
- Ball RS300 is low cost, high reliability and based on 85% space heritage components
- Selected by DOD/DARPA for Orbital Express program
- Uses proven Ball approaches that have given a highly successful track record of space flight systems
- Provides sufficient margins for AIM with minimal modifications to baseline design
- Performs twice/orbit yaw needed for science
- Conducts yaw maneuvers over the required ~ 9^0 range in polar regions



AIM science is accomplished using common volume data



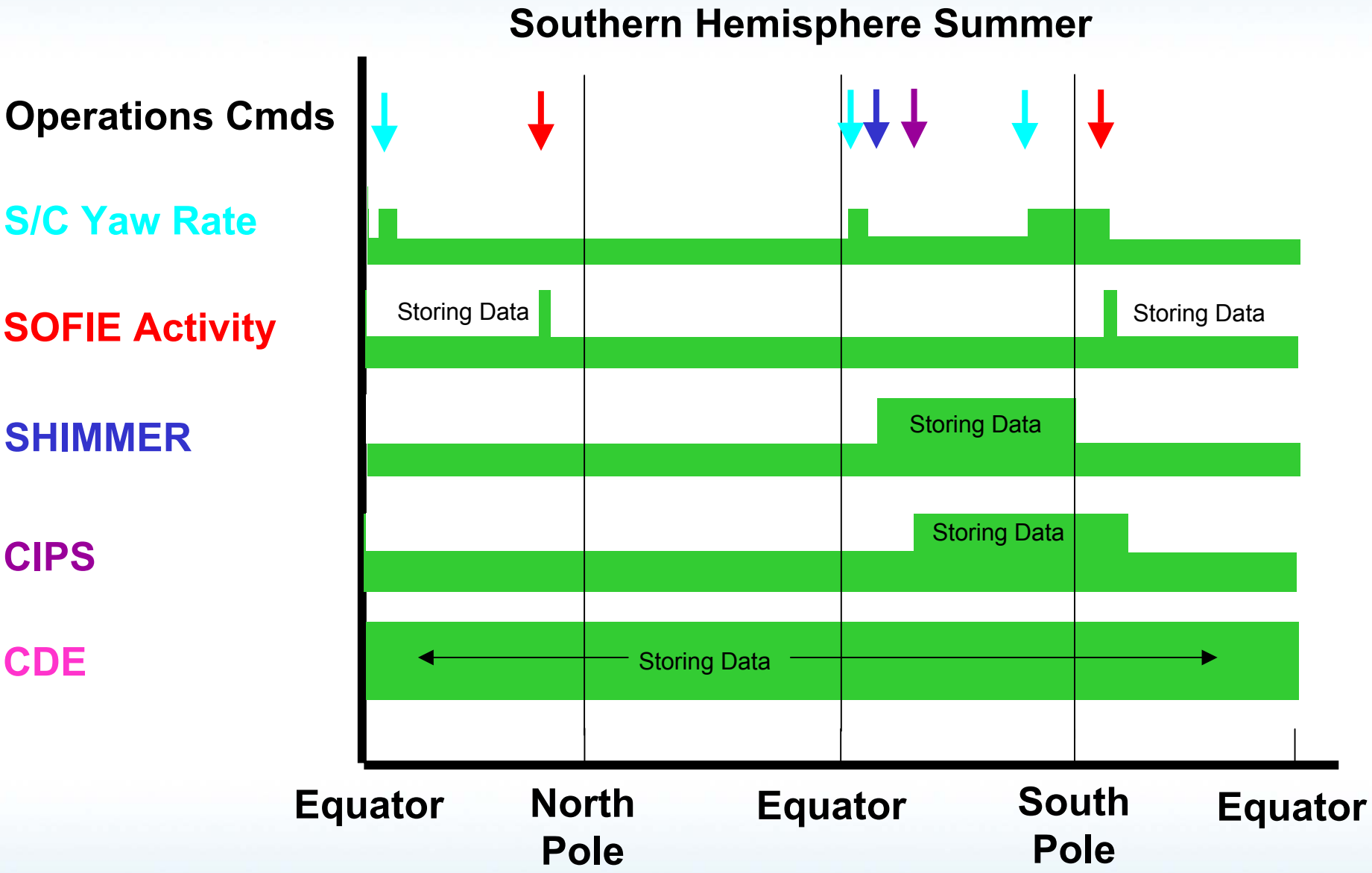
Over 700 PMCs in the Common Volume each Season



Locus of coincident measurements by SOPHIE, SHIMMER, and CIPS for a sun-synchronous, noon orbit.

SME measurements of PMC occurrence frequency.

The AIM orbital profile is straightforward and well defined



AIM mission is ideal for SMEX

- Pegasus XL-HAPS launch from Vandenberg Air Force Base
- 500 km, circular, 97.4^{o} inclination, sun-synchronous
- 23 month mission lifetime covers four PMC seasons
- No spacecraft propulsion systems needed
- 39 month development schedule

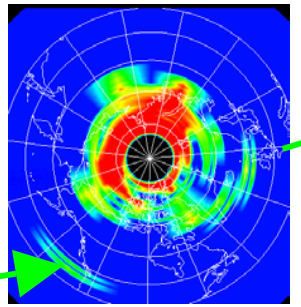
NLCs inspire awe and wonder in the public

AIM science is compelling to the public because it focuses on a changing phenomenon we can all observe.

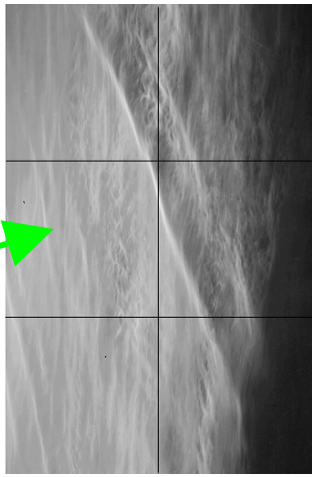
They are beautiful…

…and intriguing…

…and with increasing probability, are visible to people in many areas of the United States.



SNOE



AIM
100x SNOE Resolution

AIM will solve their mysteries

The public is already engaged in AIM science

"Several times in the last few months observers in the lower 48 have seen 'noctilucent clouds'…they're spectacular, and they're also out of place." NY Times, 4 September 1999

- **First discovered by amateur astronomer R.C. Leslie, 1885**

"…looked brighter and paler than clouds under a full moon. A friend who was with me aptly compared the light on these clouds to that which shines from white phosphor paint. This…"

Letter to the editor, *Nature*, 1885

- **Active amateur observer networks**
- **Scores of media reports**

Rocky Mtn News, 6/25/99, 7/25/99
New York Newsday, 5/31/94
New Haven Register, 5/24/94
Denver Post, 7/25/99
Sydney Telegraph, 1/29/99
Boulder Daily Camera, 8/4/94; 7/11/99
The Coloradan, 2/95, 10/99
Dallas Morning News, 9/10/99
Salt Lake Tribune, 6/24/99
Christian Science Monitor, 7/1/99
San Francisco Examiner, 6/25/99
La Porte, Indiana, Herald, 6/25/99
Sunday Monitor, Concord, NH, 7/25/99
Denver Channel 9 news, 6/25/99
Environmental News Network, 6/24/99
New York Times, 9/4/99

Idaho Mighty KGT, 6/99
NPR, 6/25/99; 11/28/01
Hispanic Radio Network, 6/28/99
ABCNEWS.com, 7/1/99
BBC "Tomorrow's World", 4/89
Current Science, 10/5/90
NationalGeographic.com, 8/12/99
New Scientist, 5/1/99
Earth in Space, 1/90
Science, vol. 253, 1488
Science News, 4/22/89
Discover, 8/89
Environment, 6/89
Smithsonian, 11/01

- **Thousands of web sites:**

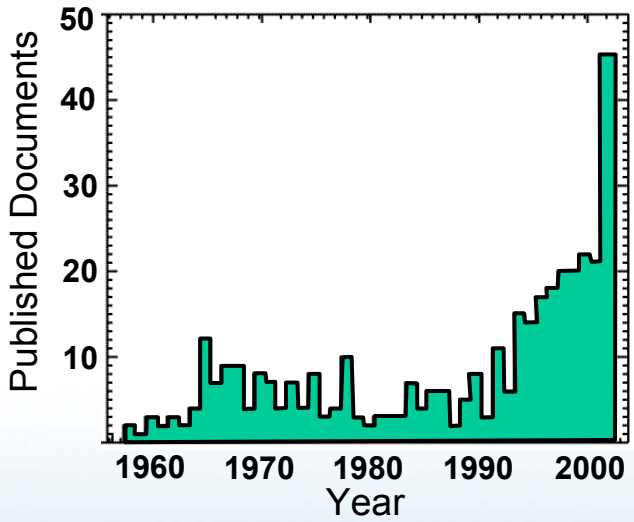
Searched the web for noctilucent clouds.

Results **1** - **10** of about **2,980**. Search took **0.12** seconds.

"Hi I am Felicia I am 9 years old. What are noctilucent clouds? Oh, I go to summer school. How do you study them? I mean the clouds…What do you try to find out about them?..." Globalclassroom.org

AIM provides dramatic progress in space science

- PMCs implicated as a harbinger of global change in the mesosphere (NRC, CEDAR)
- 1st mission designed to study clouds that exist in a near space environment
- Quantifies the seasonal evolution of water, (SEC Roadmap Quests)
- Addresses global response of the geo-space environment to solar variability and extraterrestrial forcing (SEC Roadmap Quests)
- Surging space science interest in layered phenomena in the summer polar mesosphere

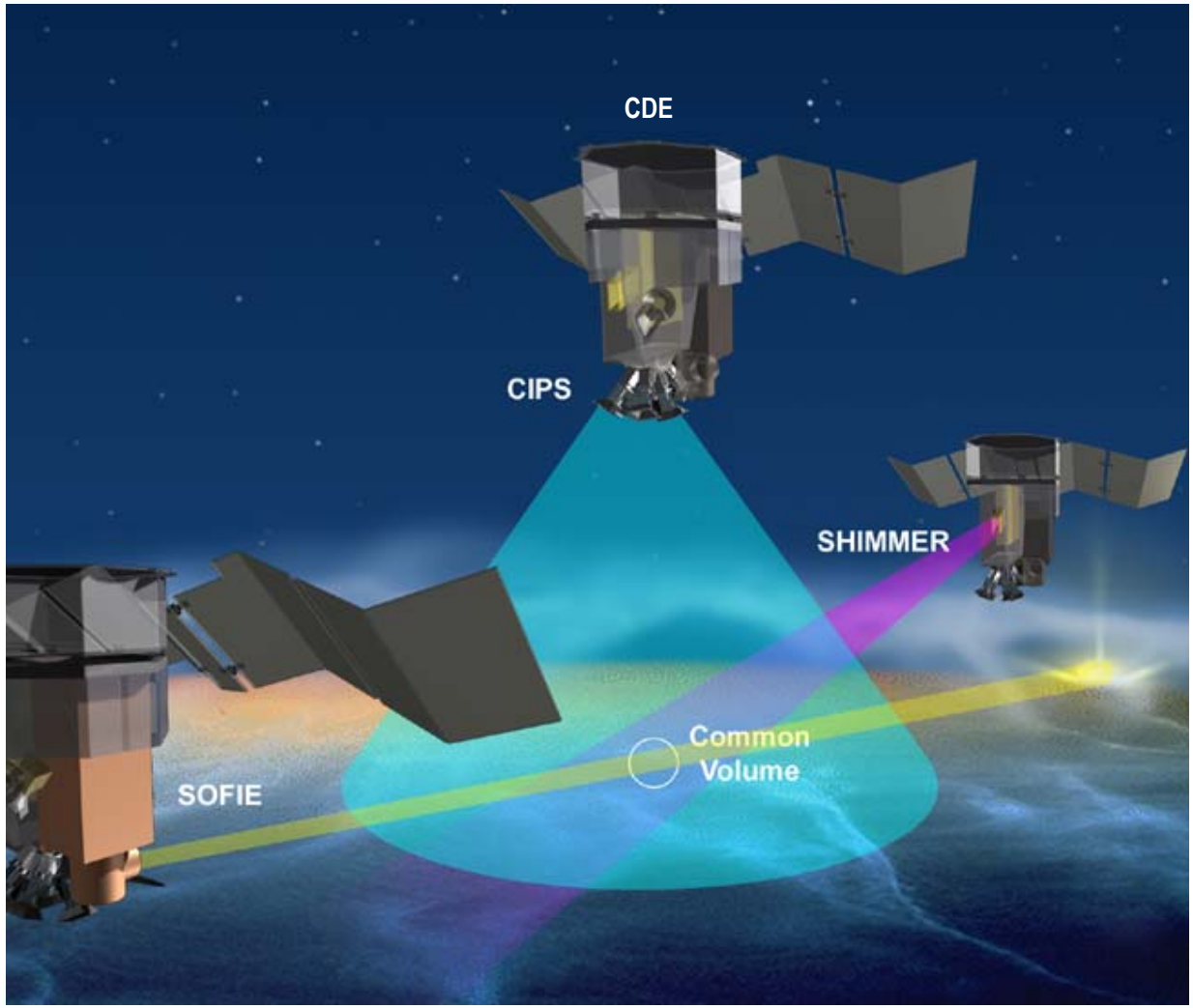


AIM Science Is Compelling

- These clouds that occur so high in our atmosphere are pleasing to the eye and mysterious to the intellect
- Why do they form and vary?
- Provides important space science advances

AIM science accomplished using common volume measurements

- SOFIE, solar occultation
- SHIMMER, limb scattered sunlight
- CIPS, high resolution panoramic images over the entire polar cap
- CDE, cosmic dust influx



AIM IPA approach reduces cost and schedule

- **Four instruments mounted to an Instrument Platform Assembly (IPA)**
  - **Instrument I&T done in parallel with spacecraft I&T**
- **IPA mounted to spacecraft after integration and checkout (approach used for SME and SORCE)**